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DEVELOPMENT OF MATERIAL SPECIFICATIONS AND QUALIFICATIONS  
OF POLYMERIC MATERIALS FOR THE JPL SPACECRAFT MATERIALS GUIDEBOOK

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by

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## I. Scope

This report covers the work performed during the period March 10 to April 10, 1965, on "Development of Material Specifications and Qualifications of Polymeric Materials for the JPL Spacecraft Materials Guidebook."

The over-all objective of this program is to provide assistance to the JPL staff members in the development of specifications and procedures for polymeric spacecraft materials. This includes definitions of properties, tests, and environments which are sensitive and meaningful, and collection of pertinent property, environmental, and materials data for use in specifications. Of particular importance to this program are the outgassing characteristics of various polymeric materials. The classes of materials to be examined were selected by the JPL cognizant engineers.

Current studies are concerned with the outgassing characteristics of liquid and paste silicones.

## II. Work Accomplished

Silicones: The effect of a higher level of curing agent in several of the RTV silicone resins was examined. The weight percent of T-12 catalyst and RTV silicones was raised from 0.1-0.2 to 0.5, and the samples were cured in the usual way. A condensable oil evolved from the silicones at 150°C and  $10^{-6}$  mm, which was initially assumed to be uncrosslinked polymer, has been identified as material of the same structural type as the polymer. This is added by the manufacturer as a plasticizer or viscosity controller. It is therefore not surprising that a higher level of curing agent had little effect on the outgassing properties of the materials tested. Outgassing data for various treatments on four of the RTV silicones are summarized on the following page:

PERCENT WEIGHT LOSS OF MATERIALS  
(after 45 hrs at 150°C/10<sup>-6</sup> mm Hg)

| Silicone | Material Prepared Using Standard Processing (0.1-0.2% Catalyst) |  | Material Prepared Using 0.5% Catalyst (not postcured) |
|----------|---|--|---|
|          | Not Postcured   | Postcured Using JPL Recommendations (150°C x 24 hrs) |   |
| RTV 60   | 1.6   | 0.8  | 1.4   |
| RTV 560  | 3.3   | 1.6  | 3.3   |
| RTV 11   | 2.7   | 1.2  | 2.2   |
| RTV 511  | 4.3   | 1.8  | 4.0   |

All materials for each treatment showed considerable quantities of condensable volatile oils. It has been noted, however, that apparently all oil evolution takes place within the first 24 hours under thermal vacuum conditions. Samples are now undergoing a vacuum postcuring at 150°C and 10<sup>-6</sup> mm for 24 hours. The thermal vacuum data for these "space-cured" samples will be available for the next report.

Epoxides: At the request of Mr. Hugh Maxwell, additional data for the development of specifications were obtained on the following adhesives: Epon 901B/3 and Epon 422J after a six-hour postcure at 177°C; and Epon 917 (cured 2 hours at 177°C). All were tested at 150°C and 3 x 10<sup>-6</sup> mm Hg. The results are tabulated below:

| Epon Resin | Initial Weight Loss |                                      | Weight Loss Rate                        | Sample Thickness  |
|------------|---------------------|--------------------------------------|---|-------------------|
|            | Percent             | g-cm <sup>-2</sup> x 10 <sup>4</sup> | g-cm <sup>-2</sup> hr x 10 <sup>6</sup> | g/cm <sup>2</sup> |
| 901B/3     | 0.794               | 2.58                                 | 0.03                                    | 0.0325            |
| 422J       | 0.946               | 3.83                                 | 0.40                                    | 0.0404            |
| 917        | 0.804               | 3.86                                 | 0.62                                    | 0.0480            |

Apparently all samples reached steady state within 24 hours.

Data Analysis: In general, the data quoted in reports have been based on the assumption that weight losses become linear with time after a large initial weight loss, i.e., that the process is of the form

$W = A + Bt$ , where A is the so-called "initial weight loss" and B is the weight loss rate. Although this treatment appeared satisfactory in the handling of 150°C weight loss data for samples examined to date, it was inadequate for describing the weight loss data of these same materials at 200°C. In this case, the weight vs. time functions exhibited noticeable deviations from linearity, becoming convex with respect to the time axis. This suggested use of the more general form:

$$W = at^b$$

This form has the mathematical advantage of being zero at  $t = 0$ , thus giving a more realistic description of the whole outgassing process.

When the 200°C data were plotted on a full logarithmic scale, good straight lines were obtained. In the case of several of the adhesives which had large weight losses, abrupt increases in the slopes were noted. This would appear to indicate the onset of material degradation. This effect is most clearly evident for Epon 924, where there is a distinct change in slope at approximately 80 hours. (See Fig. 1) The constants a and b for the epoxide adhesives at 200°C and  $10^{-6}$  mm are tabulated below, as well as the constant b' (i.e., the constant for the second slope) for those adhesives that exhibit a change in slope.

| <u>Epon Adhesive</u> | <u>a</u> | <u>b</u> | <u>b'</u> |
|----------------------|----------|----------|-----------|
| 924                  | 2.32%    | 0.237    | 0.561     |
| 4225                 | 3.56%    | 0.064    | ---       |
| 917                  | 2.30%    | 0.053    | ---       |
| 934                  | 0.96     | 0.307    | 0.403     |
| 941                  | 0.82     | 0.265    | 0.393     |
| 903                  | 0.46     | 0.385    | ---       |
| 914                  | 0.51     | 0.344    | 0.515     |
| 931                  | 0.58     | 0.337    | 0.384     |
| 901B/3               | 0.13     | 0.463    | ---       |

### III. Future Work

Work will be completed on the silicone adhesive and potting compounds within the next month. After that time, further work will be transferred from the Polymer Research Department to the Analytical Services Department, in accordance with the change in emphasis requested by JPL, until such time as more basic studies again become desirable.

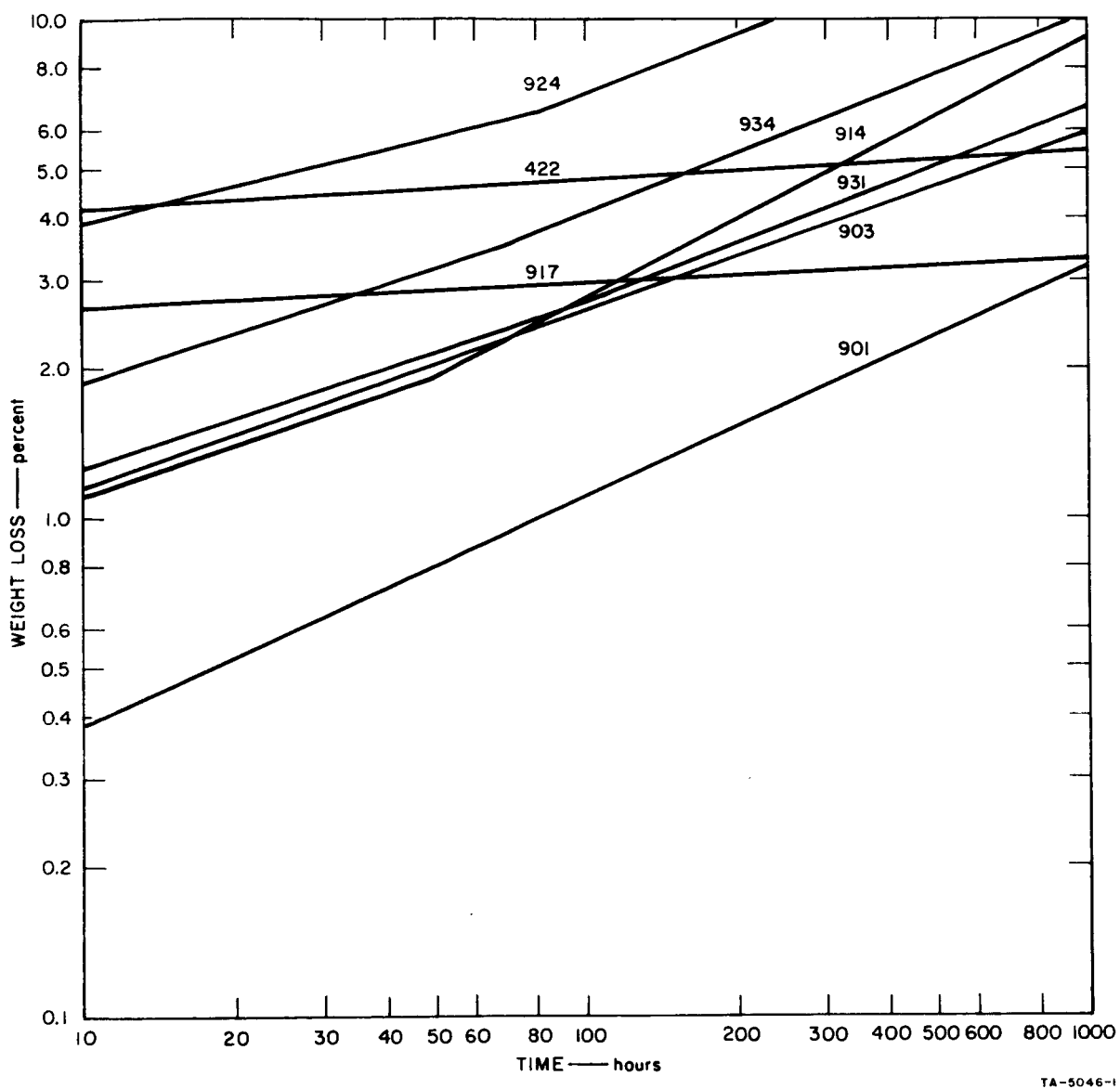


FIG. 1 WEIGHT LOSS OF EPOXY ADHESIVES (200°C × 10<sup>-6</sup> mm Hg)